

Prepared for the Seminole Nation of Oklahoma





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Background

The purpose of this study is to develop Stormwater Management recommendations for the Seminole Nation by implementing plans for development of land at the Mekusukey Mission Grounds.

The study site is located approximately two miles south and two miles west of the City of Seminole, north of SH 59, specifically in Sections 5 and 6 of T8N, R6E.

Existing Conditions Data

Boundaries of the tribal site are shown on a 2008 National Aerial Imaging Program (NAIP) aerial photo (Figure 1). The entire site covers approximately 320 acres. Figure 2 shows the site on the Seminole United States Geological Survey (USGS) 7.5 Minute Quadrangle Map. The USGS topographic data was the only topographic information available for this study.

Existing impervious areas consisting of parking lots and roofs were determined from the aerial photograph and are shown on the quad (Figure 2). Presently, there are about 5 acres of impervious area, or about 1.6% of the total acreage.

Both the aerial photo and quad map indicate the presence of two ponds on the property. The pond in Section 5 drains to a blue-line stream which is a tributary of Wewoka Creek. The pond in Section 6 drains to the west, ultimately to another tributary of Wewoka Creek. The other blue-line stream on the property is located in the northwest corner and is also a tributary of Wewoka Creek.

The aerial photo shown in Figure 3 indicates that most of the undeveloped portion of the site is grassland with scattered trees, categorized as Pasture-Fair for purposes of runoff computation. A portion of the site has sufficient density of trees to be categorized as Woods-Fair for purposes of runoff determination. The total area in woods is about 88 acres or 27% of the entire site.

Stormwater Conveyances and Direction of Flow

Presently, runoff is conveyed from the property through natural channels. Two ponds on the property provide some runoff rate and volume control, and should provide some water quality benefits. However, the extent to which they do is unknown since they were not engineered for this purpose.

There are four drainage divides on the property, as shown in Figure 4. Runoff exits the property in four separate locations. Since the property is located on a ridge, there is no runoff from off-site entering the property.

Drainage Areas (DAs) 1, 3, and 4 drain to Natural Resources Conservation Service (NRCS) structures within the Wewoka Creek Watershed, as shown in Figure 5. Drainage Area 2 drains to a tributary that flows directly to Wewoka Creek.

Existing Site Hydrology

Existing site drainage areas and flow paths are shown in Figure 4. Given the sizes of the watersheds, NRCS curve number and unit hydrograph methods (Reference 1) were selected to compute runoff. These areas were considered too large for the rational method to be valid.

For existing conditions, land use was divided into three categories: Impervious, Pasture-Fair, and Woods-Fair. A pervious area curve number for each drainage area was determined based on soils present. Hydrologic soil groups (HSG) B, C, and D were present throughout the site. Table 1 lists the curve number for each land use and soil type (source: Reference 1).

Table 1 NRCS Curve Numbers							
	Soil HSG						
Land Use	В	С	D				
Pasture-Fair	69	79	84				
Woods-Fair	60	73	79				
Impervious	98	98	98				
Commercial	92	94	95				

For DAs 1, 2, and 4, a pervious area curve number was determined by area-weighting curve numbers for pasture-fair among the soil types. The curve number was then adjusted to account for the impervious area, which was not considered directly connected to outlets from the site. Since the impervious area was such a small fraction of the total, it was not considered necessary to account for them within each soil type. Table 2 shows a computation of the curve number for Areas 1, 2, and 4. Areas in each soil group are shown in Figure 6, and materials from the NRCS soil survey are found in the Appendix.

Travel time through each drainage area was computed using NRCS's equation for velocity of overland and shallow $V = a\sqrt{S}$ concentrated flow (Reference 2):

Where "V" represents velocity in fps, "a" represents a parameter for surface cover, and "S" represents *slope* in ft/ft. Table 3 contains travel time computations; a reference for values can be found in NRCS Publication TR-55. Lag time was computed as 0.6 x travel time, in accordance with NRCS guidelines.

Table 2
Curve Numbers for Areas 1, 2 and 4

	Square Feet of Each HSG			Fraction of Each HSG			Pervious	Imp. Area	lmp.	Final Wt.	
Area	В	С	D	Total	В	С	D	CN	sq ft	fraction	CN
1	239073		1025231	1264304	0.19	0.00	0.81	81.16	66849	0.05	82.05
2	1605898	789556	747104	3142558	0.51	0.25	0.24	75.08	116162	0.04	75.93
4	1147092	138584	173171	1458847	0.79	0.09	0.12	71.73	0	0.00	71.73

CN = curve number

Imp = impervious

Wt = weighted

DA 1 impervious area includes 28,745 sq-ft water

Table 3										
Computation of Travel Time and Lag Time										
						Travel Time	e (TT)			
Area Name	Surface	а	Length, ft	Slope	Velocity, fps	Seconds	Minutes	Lag, min.	DA Total TT, min.	
DA 1	Grass	7	1433	0.023	1.06	1357	22.6	13.6	13.6	
DA 2	Paved	20.3	464	0.013	2.35	197	3.3	2.0		
DA 2	Grass	7	1431	0.032	1.25	1148	19.1	11.5	13.5	
DA 3	Grass	7	1743	0.036	1.32	1321	22.0	13.2		
DA 3	Channel	16.1	2562	0.015	1.99	1285	21.4	12.8	26.1	
DA 4	Ditch	20.3	584	0.032	3.64	161	2.7	1.6	3	

Pervious area curve number for DA 3 was weighted between soil types and land cover of woods or pasture. The result was then adjusted for the impervious area; Table 4 contains the calculations.

Table 4										
DA 3 Weighted Curve Number										
Cover	Sq ft	Fraction	CN	Weight	Impervious	Fraction	Final CN			
B grass	2017493	0.25	69	16.98						
B trees	186708	0.02	60	1.37						
C grass	1764261	0.22	79	17.00						
C trees	3474688	0.42	73	30.93						
C Water	64501	0.01	100	0.79						
D grass	162434	0.02	84	1.66						
D trees	529656	0.06	79	5.10						
Total	8199741			73.83	66808	0.0081	74.03			

Runoff was computed for 2-, 10-, and 100-year events. Twenty-four hour rainfall amounts were determined using USGS WRI 99-4232 (Reference 3) which gives depth-duration rainfall frequency data for the State of Oklahoma. Rainfall amount for the 2-year event is estimated to be 3.45 inches; 10-year event estimated to be 5.55 inches; and 100-year event is estimated to be 8.2 inches. HEC-HMS model (US Army Corps of Engineers, References 4 and 5) was used to formulate calculations. Figure 7 shows the basin model schematic. Each DA had a separate outlet so that neither junctions nor routing reaches were needed.

Proposed Development Hydrology

Areas proposed for future development are shown in Figure 8. These areas are all located in DAs 1, 2, and 4; therefore, no changes are expected to affect the runoff in DA 3 as a result of development.

Since there are no definite site plans for these proposed developments, the areas were designated as "Commercial" for purposes of calculating runoff curve number (Reference 1). Pervious curve numbers for each DA were re-weighted to account for commercial areas, as shown in Table 5. They were then adjusted for existing impervious areas, as shown in Table 6.

Table 5 Post-De	Table 5 Post-Development Pervious Curve Numbers (CN)										
	Areas, Sq.ft.			Fraction	n		Weight	Weighted CN			
DA	1	2	4	1	2	4	1	2	4		
Soil HSG B											
Open	66053	1605898	963392	0.05	0.51	0.66	3.60	35.26	45.57		
Comm	173019	0	183699	0.14	0.00	0.13	12.59	0.00	11.58		
Soil HS	G C										
Open	0	668500	0	0	0.21	0	0	16.81	0		
Comm	0	121056	138584	0	0.04	0.09	0	3.62	8.93		
Soil HS	G D										
Open	292296	479827	0	0.23	0.15	0	19.42	12.83	0.00		
Comm	732935	267277	173171	0.58	0.09	0.12	55.07	8.08	11.28		
Total	1264303	3142558	1458846	3846 Final CN 90.69 76.59 77.36							

Table 6 Final Weighted Curve Number Proposed Development							
DA Name	1	2	4				
Total Area, sq. ft.	1264303	3142558	1458846				
Existing Impervious Area, sq. ft.	66849	116162	0				
Pervious CN	90.69	76.59	77.36				
Impervious CN	98	98	98				
Weighted CN	91.07	77.38	77.36				

Table 7 shows computation of travel time and lag, which was done in the same manner as computations for existing conditions.

Table 7										
Travel Time (TT) and Lag Time for Proposed Development										
									Total	
			Length,		Velocity,	TT,	TT,	Lag,	Lag,	
Area	Surface	Α	ft	Slope	fps	Seconds	Minutes	min.	Min	
DA 1	Paved	20.3	1188	0.025	3.18	374	6.2	3.7		
DA 1	Grass	7	245	0.007	0.60	411	6.8	4.1	7.8	
DA 2	Paved	20.3	1200	0.030	3.53	340	5.7	3.4		
DA 2	Grass	7	696	0.024	1.08	642	10.7	6.4	9.8	
DA 4	Ditch	20.3	584	0.032	3.64	161	2.7	1.6	3	

HEC-HMS was used to do post-development runoff calculations. Since none of the drainage divides changed, the basin schematic was the same as for pre-development. The only differences in the model were curve numbers and lag times for Areas 1, 2, and 4.

Table 8 is a comparison of pre- and post-development runoff results taken from the HMS model. Columns were added to show increases in peak runoff rate and runoff volume. This analysis shows that the proposed development will have a significant impact on peak runoff rate.

Table 8 Comparison of Pre- and Post-Development Results											
Existing			·		Proposed						
DA	Area	Peak Q	Time of	RO Vol.	DA	Area	Peak Q	Time of	RO Vol.	Increase	Increase
Name	Mi^2	cfs	Peak	Ac-ft	Name	Mi^2	cfs	Peak	Ac-ft	In Q	In Vol.
100-year											
DA 1	0.0454	185.22	20Jun2009, 12:06	14.6221	DA 1	0.0454	259.18	20Jun2009, 12:01	17.2482	73.96	2.6261
DA 2	0.1127	413	20Jun2009, 12:06	31.9524	DA 2	0.1127	491.93	20Jun2009, 12:03	33.0177	78.93	1.0653
DA 3	0.2941	692.02	20Jun2009, 12:18	79.5302	DA 3	0.2941	692.02	20Jun2009, 12:18	79.5302	0	0
DA 4	0.0523	266.91	20Jun2009, 11:56	13.4956	DA 4	0.0523	298.81	20Jun2009, 11:56	15.3417	31.9	1.8461
10 year											
DA 1	0.0454	111.27	20Jun2009, 12:06	8.6428	DA 1	0.0454	168.97	20Jun2009, 12:01	10.9456	57.7	2.3028
DA 2	0.1127	232.6	20Jun2009, 12:07	17.9039	DA 2	0.1127	282.85	20Jun2009, 12:03	18.7483	50.25	0.8444
DA 3	0.2941	377.95	20Jun2009, 12:19	43.7526	DA 3	0.2941	377.95	20Jun2009, 12:19	43.7526	0	0
DA 4	0.0523	144.76	20Jun2009, 11:57	7.2665	DA 4	0.0523	172.86	20Jun2009, 11:56	8.7115	28.1	1.445
2-year											
DA 1	0.0454	54.42	20Jun2009, 12:07	4.2106	DA 1	0.0454	96.43	20Jun2009, 12:01	6.0475	42.01	1.8369
DA 2	0.1127	100.6	20Jun2009, 12:07	7.9305	DA 2	0.1127	126.99	20Jun2009, 12:04	8.5053	26.39	0.5748
DA 3	0.2941	153.47	20Jun2009, 12:20	18.7459	DA 3	0.2941	153.47	20Jun2009, 12:20	18.7459	0	0
DA 4	0.0523	58.55	20Jun2009, 11:57	2.9926	DA 4	0.0523	78.75	20Jun2009, 11:57	3.9521	20.2	0.9595
RO = run Vol = volu											

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Floodplain and Stormwater Management Measures

All outlets from the site eventually discharge into streams that have Federal Emergency Management Agency (FEMA) Zone A's identified; DA 3 includes a portion of a FEMA floodplain within the property. This data is shown in Figure 9 and was created using preliminary Digital Flood Insurance Rate Map (DFIRM) for Seminole County. A copy of the Flood Insurance Rate Map (FIRM) showing floodplains in the effective study can be seen in the Appendix. Since there is no proposed development in DA 3 and no change in runoff, the proposed projects will not impact the FEMA floodplain within the property. However, increased runoff will result in a rise in water surface elevation in other FEMA floodplains, as shown in Figure 9.

To be in compliance with the National Flood Insurance Program (NFIP), the increase in discharge will either need to be mitigated on-site or the Seminole Nation will need to do extensive hydraulic analysis to demonstrate that the rise in water surface elevation will be limited to one foot (or less, depending on applicable regulations). As there is open land available and topography is favorable, we recommend providing detention.

The hydrographs generated by HEC-HMS for the 100-year event were used to determine a rough volume and footprint for the proposed detention. A factor of 20 percent was added to the volumes obtained to account for freeboard and for the fact that unless the outlet has the exact stage vs discharge relationship required (almost impossible to attain) extra volume over what is calculated based on the hydrographs is usually needed.

Detention volume was calculated as the difference between the post-development volume and the theoretical routed volume, as shown in Figure 10. Figures 10, 11, and 12 show pre-development, post-development, and routed hydrographs for drainage areas affected by development. Hydrographs were computed using HEC-HMS. Table 9 below, summarizes detention volumes required.

Table 9								
Detention Volumes Required								
Drainage Area Name	1	2	4					
Calculated Volume, ft ³	84782	110049	36799					
Ac-ft (rounded)	2	2.5	0.84					
Ac-ft to store	2.4	3	1					
Surface acres with 3' depth	0.8	1	0.33					

Figure 13 shows possible footprints for recommended detention facilities. The proposed tribal complex is located in DA 1 and DA 4. Runoff from each portion of the site can be conveyed toward natural outlets by grading. A detention facility situated at the property line can control runoff so that post-project discharge rate is equal to existing conditions. The detention facility in DA 1 discharges to a channel and

ultimately to the NRCS structure located to the west. The detention structure in DA 4 discharges to the bar ditch on SH 59 and ultimately to the NRCS structure located to the east.

For DA 2, a detention facility that can intercept runoff from both proposed developments can be constructed at the property line. Natural drainage can be improved with grass channels to convey runoff to the detention, as shown in Figure 13.

To verify that grass channels are feasible, runoff into each channel was computed. Figure 14 shows drainage areas and flow paths. Table 10 contains runoff parameters for the three sub-areas A, B, and C.

Table 10									
Runoff Parameters for DA 2 Channels									
Name	Area, ft^2	Developed ft^2	Perv. CN	Devel. CN	Weighted CN	Lag, min			
Α	454348	135055	75.93	94	81.30	4.97			
В	544927	87296	75.93	98	79.47	4.00			
С	810926	273429	75.93	95	82.36	7.70			
Perv = per	vious								
Devel = developed									
CN = curv	e number								

This information was entered into the HMS model to compute peak discharges. Table 11 contains results for the 100-year event.

Table 11 Peak Discharge in Proposed Channels						
Name	Area, sq mi	Area, sq mi Peak Q, cfs				
Α	0.0163	92.41				
В	0.0195	111.36				
С	0.0291	150.36				
A and B	0.0358	202.61				

Proposed channels were designed to convey the 100-year peak discharge in a trapezoidal channel with 4:1 side slopes. Bed slopes followed the natural ground. To have a stable channel, depth and width combination was selected to maintain a velocity less than 4 feet per second.

Manning's formula was used to solve for depth and width. Depth and width are determined such that the following equations are satisfied:

Discharge (*Q*) calculation:

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Area (A) Calculation:

$$A = (BW)D + ZD^2$$
 $BW =$ bottom width, ft.; $D =$ depth, ft.; $Z =$ side slope H:V

Hydraulic Radius (R) Calculation:

$$R = \frac{A}{WP} = \frac{A}{BW + 2D\sqrt{1 + Z^2}}$$
 WP = wetted perimeter

n is Manning's Roughness. A value of 0.04 was used, obtained from Reference 6. S is the channel slope in ft/ft (V:H).

Table 12 contains channel calculations with the widest channel being 102 feet. There is enough open land to accommodate this and smaller channels as well.

Table 12										
Proposed Channel Properties										
Area A Channel		Area B Channel		Area C Channel		DS of A and B				
Depth, ft	0.62	Depth, ft	0.33	Depth, ft	1.25	Depth, ft	0.51			
BW, ft	34.9	BW, ft	82.3	BW, ft	25.9	BW, ft	98.45			
Z	4	Z	4	Z	4	Z	4			
Area, ft ²	23.1	Area, ft ²	28.04	Area, ft ²	38.66	Area, ft ²	51.49			
WP, ft	40.0	WP, ft	85.15	WP, ft	36.24	WP, ft	102.67			
R, ft	0.58	R, ft	0.33	R, ft	1.07	R, ft	0.50			
n	0.04	n	0.04	n	0.04	n	0.04			
Slope, ft/ft	0.024	Slope, ft/ft	0.05	Slope, ft/ft	0.01	Slope, ft/ft	0.028			
Q, cfs	92.41	Q, cfs	111.36	Q, cfs	150.36	Q, cfs	202.61			
V, fps	4	V, fps	3.97	V, fps	3.89	V, fps	3.93			
Top Width, ft	39.88	Top Width, ft	85.07	Top Width, ft	35.93	Top Width, ft	102.55			

WP = wetted perimeter

DS = downstream of the confluence of Channels A and B

V = velocity = Q/A

Construction Sediment Control

To comply with Construction General Permit OKR10 (reference 7) a Stormwater Pollution Prevention Plan (SWPPP) describing sediment control Best Management Practices (BMPs), among other issues, will be needed. The Transit Center and Cultural

Center involve a disturbance of less than 10 acres so that perimeter controls are sufficient. The proposed tribal complex, if constructed all at once, could disturb an area greater than 10 acres making a sediment trap providing 3600 cubic feet of storage for each acre disturbed a requirement. Proposed DA 1 detention may be used as a sediment trap during construction then converted to permanent detention once construction is completed. The existing pond within the proposed tribal complex area should be protected with sand bags, jute logs, or equivalent. Figure 15 shows recommended sediment controls.

Environmental Features

An inventory of environmental features, which could impact proposed projects, was completed using data from Oklahoma Water Resource Board (OWRB), +Department of Environmental Quality (DEQ), etc. There are no sensitive waters, critical habitat areas, wellhead protection areas, or surface water intakes located on the property. There is one monitoring well, shown in Figure 16.

Two existing impoundments on the site are indicated as Freshwater Pond wetlands on the National Wetlands Inventory (NWI), shown in Figure 17. The larger pond located in DA 3 will not be impacted by said proposed development. We would recommend that, as part of the construction plan phase, the pond within the proposed tribal complex be surveyed and a biologist consulted to determine if it is, in fact, a wetlands. Please note that there are many areas listed on the NWI that are not wetlands. If it is deemed a wetland, recommended protection of sand-bagging should be reviewed to determine adequacy.

<u>Planning and Development Considerations</u>

The study site presents many opportunities to provide aesthetic, recreational and environmental benefits. Several examples are described here and illustrated in Figure 18. Please note this is for illustration purposes only. We strongly recommend a Master Plan be developed by a team representing disciplines in recreation planning, architecture, ecology, horticulture and landscape architecture, and forestry (in addition to engineering and stormwater management).

<u>Riparian Corridor:</u> This involves dedicating a conservation easement to restrict building, paving, and vehicular traffic (except as needed for bank and vegetation maintenance) in the vicinity of the channel downstream of the lake. The corridor shown in Figure 18 corresponds to the floodplain shown on the FEMA map. Preventing the encroachment of buildings and fill for other purposes into this corridor will aid in protecting natural and beneficial uses of this floodplain.

<u>Woodland Preserve:</u> Preservation of mature trees benefits habitat, reduces soil erosion, improves air quality, and reduces any heat island effects from buildings and

pavement. Three stands of mature trees have been recommended as woodland preservation areas (Figure 18). We recommend that the areas be surveyed by a professional forester to develop a plan of culling (if needed) and understory maintenance to promote a healthy stand and also to develop a list of what size and species of trees to protect. Any future construction or development within these areas should be done without disturbing any trees in the listed categories.

Recreation and Meeting Facilities: The open area located east of the property represents a good location for picnic grounds, pavilion, or possibly a building with meeting facilities, rest rooms, etc. Development in this area should be possible without disturbing woodland or riparian areas. The site would be accessible by an all-weather roadway, located in an existing break in wooded areas, as shown in Figure 18. The ability to provide water and sanitation to the site will be a factor in determining exactly what facilities may be constructed.

<u>Hiking Trails</u>: Hiking trails shown in Figure 18 were designed to provide a variety of different distances that could be hiked without having to double back over the same trail. These originate near existing buildings where parking is available. For foot travel only, gravel surfaces are acceptable and would not increase impervious area and runoff. If trails are to be designated for walking and biking trails, use of porous asphalt can minimize the impact of a paved surface on the amount of runoff for the site.

Horticulture Education and Preservation: Grass channels recommended as part of the new development present opportunities to provide an educational showcase of native plants, which also have environmental benefits. We recommend that a botanist or horticulturist be consulted to recommend deep-rooted native species for planting on channel beds and banks, as opposed to typical Bermuda grass. Typically, these plants are tolerant of both drought and temporary saturated conditions, and once established require little or no maintenance. These types of plants are generally deep-rooted, which promotes bank stability and infiltration, thereby reducing the amount of runoff leaving the site. Walking paths with placards identifying species could be constructed along channels to introduce visitors to the beauty of native species. In turn, this would possibly motivate visitors to incorporate native species into their own landscaping, as opposed to exotic and potentially invasive species often used in residential landscaping.

Innovative Stormwater Management Techniques

There are a variety of innovative stormwater management facilities, also known as BMPs, which may be incorporated into development sites. Examples of these and their potential benefits are listed below. Again, development of a comprehensive, multi-disciplinary Master Plan that includes the development sites and the remainder of the mission grounds, are recommended to obtain optimum benefits. The benefit to be achieved from these measures depends largely on soil and climate conditions, therefore, site-specific evaluations are recommended.

<u>Bioretention Cells ("Rain Gardens"):</u> These facilities are situated to receive stormwater runoff and promote infiltration. They can be very beneficial when placed as traffic islands in parking lots by promoting infiltration and reducing runoff (particularly in smaller, more frequent storms). They also can provide water quality benefits by trapping sediment and other pollutants that wash off parking lots. Typically, they also provide landscaping features and are planted with deep-rooted species that promote infiltration.

<u>Porous Pavement:</u> Porous asphalt or concrete is suitable for low-traffic areas, such as parking areas that receive infrequent use, or drives and alleyways that have light usage that are not traveled by heavy trucks. Porous pavement reduces the amount of runoff, particularly in smaller storms.

<u>Vegetated Buffer Strips:</u> Vegetated buffers can be effective at trapping sediment from small impervious areas and improving water quality of runoff before it enters a channel or creek.

Conclusions and Recommendations

With runoff and sediment controls implemented, these proposed projects should have a minimal and temporary impact on runoff and water quality off-site.

Existing natural features of the site present many opportunities to provide recreational and health benefits in addition to preserving and enhancing the natural environment. Further environmental benefits may be realized through use of innovative stormwater management BMPs. We recommend that a multi-disciplinary team be assembled to create a Master Plan for the site to achieve optimum benefits from natural and constructed features.

The recommendations in this report are conceptual in nature and based on existing data. Prior to any construction, we recommend that an up-to-date topographic survey by a registered Land Surveyor be obtained, and construction plans be prepared by a registered Professional Engineer.

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